

the atmosphere is forced through the flame, which causes the nitrogen and oxygen to unite, when it passes through reservoirs of water, forming nitric acid, which may be combined with the potash and so applied to the soil.

As the nitrate beds become smaller the cost of the natural nitrates will become more costly, and the process of the manufacture of artificial nitrogen compounds will be inevitably improved and cheapened, and it will take its place among the world's greatest manufactures.

4. Recent modifications of the internal combustion engine.

Although it has been 30 years since Dr. Otto devised his gas engine of that name, a very important modification of it was made within 25 years. The chief authority for the modification was Daimler, followed by Panhard and Levasser, who substituted for the gas a volatile oil such as gasoline, to be mixed with air from the carbureter, as a definite explosive gas, which was ignited by a hot tube or electric spark at the time of the compression. This modification allowed the use of a small, rapid revolving engine, of light weight and contracted space, which gave for the first time a practical motive power for vehicles. The automobile, one of the marvels of modern industry, the flying machine, with its high powered, yet light motor, and great ocean-going ships, using this motor, are transforming modern life, and yet they are the direct result of this modern modification of the internal combustion engine.

5. Flying machines.

It is a natural step from the motor to the flying machine. The flying machine is peculiarly an American invention. Professor Langley's classical experiments near Washington were the first scientific undertaking to solve the problem of flying through the air with a machine heavier than air. His experiments, formulated in the Langley's Law, clearly demonstrated the practicability of the aeroplane.

A few years later, working with gliding machines, the two Ohio brothers, Wilbur and Orville Wright, arrived at conclusions similar to those of Langley, but they had the practical inventive genius to construct a biplane with warping wings, which demonstrated to the world for the first time that men could fly at will through the air, with or against wind currents, in a machine heavier than air.

If military necessity has driven France and Germany to advance faster than America in the practical development of the flying machine, the courts of these same countries have granted the Wright brothers their justifiable claims to priority.

6. The apparatus for producing the X-ray.

All of the elements of the X-ray apparatus were known before Professor Röntgen used them for a definite purpose. It is true that it was by pure accident that Professor Röntgen discovered that a photograph plate exposed to the cathode rays of a vacuum tube, became light struck through bodies opaque to the rays of light

but pervious to cathode rays. But the fact would have escaped the notice of any observer less great than Röntgen. He was studying the cathode rays, and to his scientifically equipped mind there was nothing of the impossible in the idea that substances opaque to the shorter rays of light—the one sixty-fourth thousand of an inch—may be easily penetrated by rays enormously less than these.

The usefulness of the X-ray apparatus became at once an invaluable aid in diagnosis to the surgeon, showing the exact condition of broken or dislocated bones, the exact location of foreign bodies in the tissues, so that they may be successfully removed, even from the brain itself; for the physician; the position and dimensions of the heart, the liver, the presence of aneurisms and tumors, cavities in the lungs, stone in the kidney, and after the administration of bismuth, the outlines and malpositions of the hollow viscera. It has become a standard treatment in certain skin affections, and as an after treatment following the removal of cancer. It is a necessary equipment of every modern hospital. No one has ever disputed Professor Röntgen's position as the first user of the X-ray in photography, and he was awarded the Nobel prize in 1901.

7. Process work for reproducing illustrations.

One has but to look into any old book or magazine to see the paucity of illustrations. The reason of this was that each illustration had to be hand engraved on steel or cut in wood, both tedious and expensive, and totally out of the question for the use of frequent publications, such as newspapers.

The accuracy and speed of the photograph has been called upon here, with the result that "half tone," and even three-color reproduction are so rapidly, cheaply, and satisfactorily done, that even the daily papers can afford to illustrate their text so voluminously, and within a few hours after the photograph has been taken. The process is based upon the fact that a gelatine, sensitized film upon a zinc block, exposed to light through a negative shrinks or swells according to the degree of light. The film is then developed, inked and subjected to an acid bath which eats away the metal unprotected by the ink.

The refinement of this process, that of "half tones," is the use of a screen of minute dots or lines ruled upon glass, between the negative and the prepared zinc block. This permits the use of such photographs that do not present the strong contrasts of light and shade. Mr. Fredrick Eugene Ives of Philadelphia was the inventor of the "half tone" process, as he was also of the first practical blocks for three-color printing.

8. The flexible photograph film.

The development of the flexible transparent film in 1888 by the Eastman Kodak Company was the most important advance in photography, for it made it not only possible for travelers and explorers to take with them sufficient rolls of films for long journeys without prohibitive weight and to bring back to civilization pictures of life of inestimable value, but it made it at last possible for the rapid development of that great

modern institution, the moving picture.

And the value of moving pictures is scarcely yet appreciated. So far they have been used chiefly for amusement, but they are destined to prove of powerful educational value.

9. The electric furnace.

When an abundance of electricity was made available by the Niagara Falls Electric Plant, the electric furnace became possible. It had long been known that many electro-chemical reactions needed but an intense heat. This the electric arc furnishes. At once manufacturers went to Niagara or vicinity to utilize it.

Already a fine grade of amorphous graphite is manufactured there, there is the possibility of artificial gems being produced by this intense heat under great pressure, but the great industry it has given rise to has been the manufacture of aluminium. This metal, once a rare and costly curiosity, is now being manufactured by the thousands of tons at near the cost of copper. Its uses are being multiplied daily, and it is destined to be the most useful and economical of metals, for its distribution as alumina is world wide and unlimited in quantity.

The manufacture of aluminium is now a very simple process, owing to the discovery by Charles M. Hall, while a student in college, that the mineral cryolite will absorb alumina to one fourth its bulk.

The heat of the electric current fuses this mass and the electrolytic action of the current deposits the metal aluminium at one of the poles. By the addition of alumina the process becomes continuous.

10. Wireless telegraphy.

Just as the elements of the X-ray machine were known before Professor Röntgen, so the elements of wireless telegraphy were known before Marconi.

In 1886 Dr. Hertz discovered waves of ether of greater amplitude than light waves and called the attention of scientists to them for their possible use in wireless telegraphy.

The sending of the messages was simple enough, the difficulty was in catching them at the receiver. This was made possible by the invention of the "coherer" by Dr. Branly in 1890. Now all the essential elements for successful wireless were known. Indeed Sir Oliver Lodge in 1893 in England and Professor Popoff in 1895 in Russia did send wireless messages over short distances through the air.

But Marconi about 1894-96 took all these crude and incomplete models, invented a practical coherer of great simplicity and sensitiveness, and added the very essential adjunct, the long air wires.

With this apparatus he within a year sent his messages across the English Channel, and in 1901 received the first trans-Atlantic wireless between England and Newfoundland. So Marconi justly enjoys the honor of being called the real inventor of Wireless telegraphy.

It is needless to dwell upon the value and importance of wireless telegraphy. Every reader from his own knowledge, will place it high among the great inventions of modern times.

Our Universities and Industrial Research*

By A. D. Little

IN view of the evidence offered by Germany of the far-reaching benefits resulting from the close co-operation which there obtains between the university laboratory and the industrial plant, it must be admitted with regret that our own institutions of learning have, speaking generally, failed to seize or realize the great opportunity confronting them. They have, almost universally, neglected to provide adequate equipment for industrial research, and, which is more to be deplored since the first would otherwise quickly follow, have rarely acquired that close touch with industry essential for familiarity and appreciation of its immediate and pressing needs. There are happily some notable exceptions.

Perhaps foremost among them stands the Massachusetts Institute of Technology with its superb engineering and testing equipment, its Research Laboratory of Applied Chemistry and the meritorious thesis work of its students in all departments. The Biological Department has been especially active and successful in extending its influence into industrial and sanitary fields, while unusual significance attaches to the motor vehicle studies just concluded and the more recently inaugurated special investigations in electricity, since both were initiated and supported by external interests. About two years ago the Institute brought vividly before the community the variety and extent of its widespread service to industry by holding a Congress of Technology, at which all of the many papers presented recorded the achievements of the Institute alumni.

The Colorado School of Mines, recognizing that \$100,000,000 a year is lost through inefficient methods of ore treatment, has recently equipped an experimental ore dressing and metallurgical plant in which problems

*Extracts from Presidential Address before the American Chemical Society.

of treatment applicable to ores of wide occurrence will be investigated. The Ohio State University has established an enviable reputation for its researches in fuel engineering. Cornell has been especially alive to the scientific needs of industrial practice, and a long experience with technical assistants enables me to say that I have found none better equipped to cope with the miscellaneous problems of industrial research than the graduates of Cornell. It may be in fact stated generally that the quality of advanced chemical training now afforded in this country is on a par with the best obtainable in Germany, and that home-trained American youth adapt themselves far more efficiently to the requirements and conditions of our industries than do all but the most exceptional German doctors of philosophy who find employment here.

Several of the great universities of the middle west, notably Wisconsin and Illinois, have placed themselves closely in touch with the industrial and other needs of the community and are exerting a fundamental and growing influence upon affairs. In the East, Columbia has recently established a particularly well equipped laboratory for industrial chemistry and is broadening its work in this department.

The Universities of Kansas and of Pittsburgh are carrying forward an especially interesting experiment in the operation of Industrial Research Fellowships supported by the special interests directly concerned. These fellowships endow workers for the attack of such diverse subjects as the chemistry of laundering, the chemistry of bread and baking, that of lime, cement and vegetable ivory, the extractive principles from the ductless glands of whales, the abatement of smoke nuisance, the technology of glass, and many others. The results obtained are intended primarily for the benefit of the supporters of the individual fellowships but may be published after three years. The holder of

the fellowships receives a proportion of the financial benefits resulting from the research, and the scale of sums allotted has progressively risen from \$500 a year to \$2,500 and even to \$5,000. While some doubt may reasonably be expressed as to the possibility of close individual supervision of so many widely varying projects the results obtained thus far seem entirely satisfactory to those behind the movement.

Research in the textile industries has been greatly stimulated by the various textile schools throughout the country, of which the Lowell Textile School with its superb equipment is perhaps best known. The fermentation industries have been brought upon a scientific basis largely through the efforts of the Wahl-Henius Institute at Chicago and other special schools.

There is no school of paper making in the country and one of our most urgent industrial needs is the establishment of special schools in this and other industries for the adequate training of foremen who shall possess a sufficient knowledge of fundamental scientific principles and method to appreciate the helpfulness of technical research. The Pratt Institute at Brooklyn has shaped its courses admirably to meet this demand.

Speed Control by a Rotary Fan.—In a patent 1,068,097 Rueben B. Benjamin, of Chicago, Ill., assignor to Benjamin Electric Manufacturing Company has patented an explosive engine governor for automobiles in which is provided a controlling mechanism by which the carburetor of the engine may be set to feed a definite amount of fuel to maintain the speed of the engine at a predetermined point. The controlling mechanism includes a rotary fan driven at a speed corresponding to that of the motor and having a movable member operated by variations in air pressure on the blades of the fan due to variable speeds of the fan. This movable member operates upon the throttle of the carburetor.

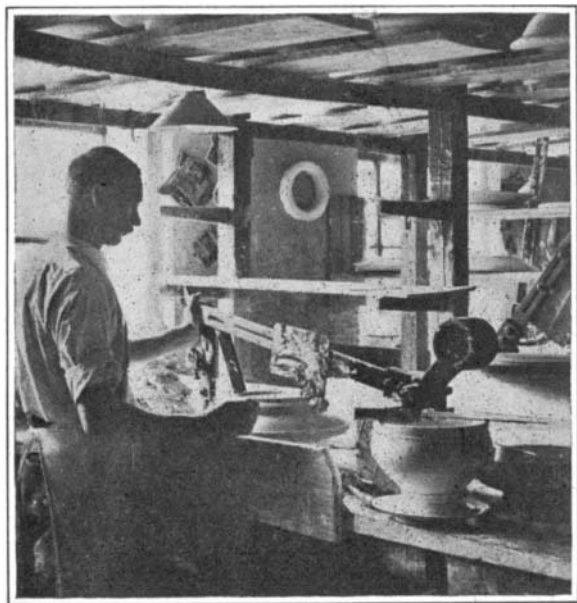


Fig. 1.—Manufacture of plates and dishes.

Circular objects, such as dinner plates, round dishes of all kinds, etc., are "turned" to shape on rapidly rotating platform, with the aid of suitable templates.



Fig. 2.—Decorating by metachromotype.

The metachromotypes are laid upon the china, moistened with water, rolled tight, and the paper drawn off. The article is then fired in a furnace at about 800 deg. Cent.



Fig. 3.—The process of gold stamping.

Certain gold ornamentations are most satisfactorily produced by a process known as stamping, but gold is generally applied with a brush.

Porcelain

Its Manufacture and Decoration

By Dr. Alfred Gradenwitz

THOUGH Germany, the cradle of European porcelain industry, has always been among the countries producing some of its most beautiful creations, the general stagnation of German decorative art in the nineteenth century left its mark also on this field of industry. While the Royal Manufactories and some private works were successful in keeping up the traditions of careful work and high quality, the strong life formerly pulsating in this productive and creative industry seemed definitely to have gone out.

However, this temporary sterility at length resulted in a reaction on the part of the leading artists, and when, in 1900, the Copenhagen Porcelain Factories celebrated unprecedented triumphs at the Paris World's Fair, they definitely found their way back to their former prosperity and leading position. In fact, the last ten years have witnessed a powerful advance in the German porcelain industry, both in quantity and in the artistic quality of products.

By the courtesy of a manufacturing firm of Selb, Bavaria, we are enabled to illustrate and describe the various departments of their works, which are claimed to be the largest factories of high-grade porcelain.

The raw materials of porcelain, as is well known, are mainly kaolin or porcelain clay, feldspar and quartz. A pure, white and spotless mass, of course, can only be made from pure raw materials, free from iron. Such perfect raw materials, however, are of rather rare occurrence. German factories use, for their best products, nearly exclusively the kaolin of Zettlitz, Bohemia, and Swedish feldspar and quartz.

The enamel of porcelain mainly consists of the same materials as the mass proper, except that it contains a

higher percentage of the flux required to produce the vitreous glazing; it is generally prepared from ground porcelain fragments, to which feldspar, chalk or dolomite are added.

The effect of each of the raw materials is as follows:

Kaolin is the essential ingredient which gives to its mass its plastic character. On the other hand, it suffers no appreciable shrinkage or deformation under the action of high temperatures, but is merely hardened and consolidated thereby.

Feldspar and quartz tend to diminish the plasticity of kaolin, and aid in the drying process. Feldspar in the fire melts into a milky glass fluxing together the refractory structure of the clay. It also partially dissolves the quartz at higher temperatures.

Chalk and dolomite exert effects similar to those of feldspar, acting as fluxes and a surplus of such fluxes as present for example in porcelain enamel, results in a glassy, shining surface.

The first stage in the treatment of these raw materials consists in crushing and mixing them most intimately by means of special machines. Feldspar and quartz are first crushed between grindstones, and then in ball mills iron cylinders containing loose flint balls. The material is here ground into a fine powder or, if it be mixed with water, into a thin pulp. Kaolin is then added in large stirring troughs. The thin paste thus obtained is passed through filter presses, and there deprived of the bulk of its water. On leaving the press, the mass is stored in cement lined cellars, and finally just before use, is subjected to beating and pressing in

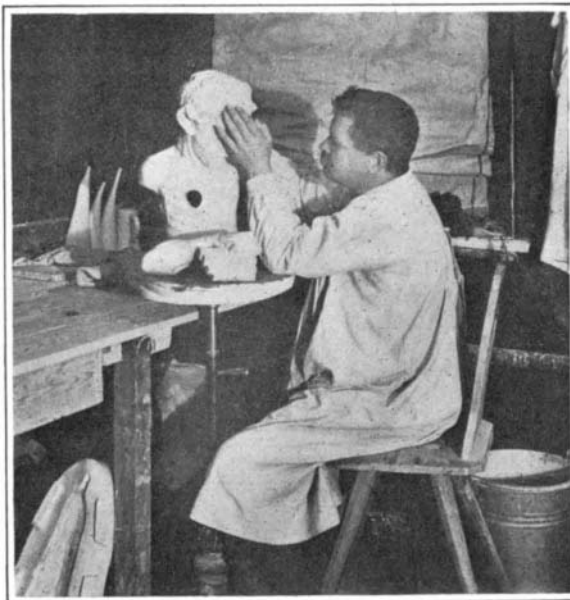


Fig. 4.—In the statuary department.

Statues are molded in a number of part molds, and the seams left at the places where molds join are carefully gone over by hand.

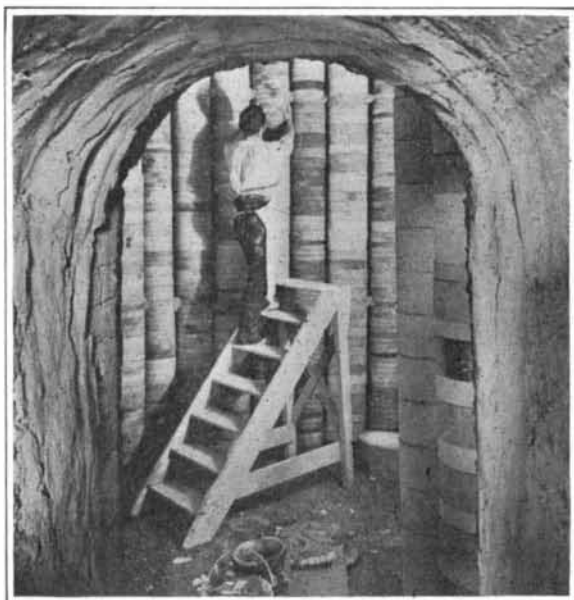


Fig. 5.—Charging a furnace.

Each porcelain article is inclosed in a separate protecting box, and these boxes are stacked up in piles in the firing furnace.



Fig. 6.—Casting china.

The plastic mass is reduced to a thin pulp by the addition of water and alkali, and in this form can be cast in absorbent molds.



Fig. 7.—In the enameling department.

The articles are dipped in a thin liquid glaze. The porous porcelain absorbs the glaze and remains covered with a coating subsequently hardened in the furnace.